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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/559,757
Filing Date: April 27, 2000
Appellant(s): OZAWA ET AL.

David L. Soltz
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 02/06/2006 appealing from the Office action mailed 06/28/2005.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after non-final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

6,414,352	Hisamune	7-2002
6,707,120	Aminzadeh et al.	3-2004

Wolf et al. "Silicon Processing for VLSI Era" Vol. 1, (1986) chapters 6-7

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 8-15 and 20-21 are rejected under 35 U.S.C. 103(a) as being unpatentable over appellant's admitted prior art in combination with Hisamune US Patent No 6,414,352 B1, Aminzadeh et al. US Patent No 6,707,120 B1 and Wolf et al., Silicon Processing for VLSI Era, vol. 1, chapters 6-7.

In the description of fig. 15A <u>of the prior art, the appellant discloses</u> that an insulating film 95 containing silicon and nitrogen is formed on the substrate 91; a film 93 which must be processed and which contains silicon is formed on the insulating film; those films are processed such that a portion of the insulating film is exposed to the outside; the structure obtained in the previous steps is subjected to an oxidation process (the instant specification, page 7, lines 4-5; page 18, lines 21-22; page 20, line 26 to page 21, line 1).

<u>The appellant's admitted prior art does not provide</u>, in the oxidation step, a surface of the semiconductor substrate is lowered, oxidizing gas containing one of ozone and oxygen radicals, the oxygen radicals being generated by remote plasma oxidizing method or by reacting a first gas containing oxygen and a second gas containing hydrogen and a concentration of nitrogen of the part of the insulating film under an edge portion of the film being decreased by the thermal oxidation process.

<u>The Hisamune reference discloses</u> conventional oxidation processes are required after forming the gates (col. 2, lines 56-57) and recognizes prior to its invention that "in the oxidation processes, oxygen radical created within a furnace easily diverges

through the separating regions in the form of silicon dioxide and reaches the gates... This encroachment of the oxide into the bottom of the gates is known as a 'gate bird's beak' because of its shape when viewed in cross-section" (col. 2, line 64 to col. 3, line 7). The prior-art recognition of Hisamune in the bird's beak formation *(to an insulating film including silicon and nitrogen, col. 1, lines 24-44)* accords with <u>the teaching of Wolf et al.</u> pages 198, 202, 211, 215-221, 227-228 on Thermal Oxidation *wherein "both nitride and nitroxide films serving as the gate dielectric" (page 211's lines 15-16)*, chapter 7 *wherein the surface of the semiconductor substrate is lowered (fig. 3, page 202)* and pages 183-187, 191-195 on Chemical Vapor reaction, chapter 6 *wherein plasma oxidation and oxygen/hydrogen reacting are taught (fig. 7, page 171, fig. 6, page 170, fig. 8, page 172, page 184 and fig. 18, page 186, e.g.)*.

<u>The appellant's admitted prior art teaches</u> "bird's beak oxidation owing to the post oxidation" (the instant specification, page 20's last line) <u>although</u> "becomes insufficient" (page 21), there must be some degrees of swelling of bird's beak formation under many variable parameters such as the concentration of nitrogen in the silicon nitroxide film at the gate dielectric layer is not high enough; and <u>though</u> <u>the Hisamune reference concerns</u> about the gate bird's beak free technology (col. 1, line 9 and col. 3, line 6) <u>its recognition</u> of bird's beak formation exists in prior art when applying oxidation to an insulating film including silicon and nitrogen.

<u>It would have been obvious</u> to one of ordinary skill in the art at the time of the invention <u>to provide</u> the oxidation process to appellant's admitted prior art structure (as of instant fig. 5A) <u>with</u> oxidizing gas containing one of ozone and oxygen radicals of

Hisamune, supported by Wolf et al. because the oxidizing gas containing one of ozone and oxygen radicals, *the oxygen radicals being generated by remote plasma oxidizing method (Wolf's fig. 6, page 170, fig. 7, page 171, fig. 8, page 172, e.g.) or by reacting a first gas containing oxygen and a second gas containing hydrogen (Wolf's page 184 and fig. 18, page 186, e.g.),* as recognized as conventional by Hisamune would provide the oxidation process of appellant's admitted prior art with improved/strengthened gate dielectric film and having the bird's beak oxidation become sufficient.

"Lowering a surface of the semiconductor substrate under a part of the insulating film than a surface of the semiconductor substrate under the film which is processed to cause the portion of the insulating film to be exposed to the outside by applying a thermal oxidation process to a semiconductor structure obtained in the step of an oxidation process by using the oxidizing gas containing one of ozone and oxygen radicals" is also recognized by Aminzadeh et al., figs. 2, 6 and the corresponding passages, (the evidence/indication of "lowering the surface" is supported by Wolf et al.'s fig. 3, page 202.) Further, with the explanation of Wolf's fig. 2, page 201, in according to fig. 3, page 202, the incorporation of oxidant into the Si/SiO_2, in this case the insulating film containing silicon and nitrogen, would reduce the concentration of nitrogen of the part of the insulating film under an edge portion of the film by the thermal oxidation process.

Re claim 20-21, the Wolf et al. reference teaches, in fig. 4, page 205, a plot at various temperatures between 700 and 1300 ^{O}C as a function of oxidation time.

Choice of temperature within a particular time frame would have been a matter of routine optimization because temperature and time are known to affect device properties and would depend on the desired device density on the finished wafer and the desired device characteristics. One of ordinary skill in the art would have been led to the recited temperature through routine experimentation to achieve desired deposition and reaction rates.

Although Wolf et al. teaches broadly nitridation of silicon dioxide (page 210), the Wolf et al. reference does not teach the step of subjecting this particular structure to at least one of a nitriding process and an additional oxidation process. "Improvement in the quality of the film owing to recovery of the process damage becomes insufficient" (admitted prior art, page 21, lines20-22).

The Aminzadeh et al. reference discloses a process of Kusunoki et al. in IEEE IEDM, vol. 91, wherein the re-oxided nitrided oxide applied on the gate structure could increase the thickness of side oxide 201, fig. 2 and last line of col. 1. With its own invention, the Aminzadeh et al. reference discloses "the poly reox step forms oxide 600 on the gate electrode 403, and also increase the thickness of gate oxide 404 over the areas that will become the source and drain regions", col. 3, last line to col. 4, line 2. The "oxide 600 is then nitridated to strengthen the oxide", "the nitridation can be performed in a furnace or a RTP", col. 4, lines 22 and 34-35. The gate structure is subjected to the oxidizing process to at least one of nitriding process and an additional

oxidation process as in fig. 7 and the related explanation in col. 4, line 42 to col. 6, line 30.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to apply further the nitridation and anneal steps of Aminzadeh et al. into the above combination of Hisamune with appellant's admitted prior art as a further process step would be selected in order to strengthened the gate dielectric film in accordance with the nitridation and oxidation step as taught by Aminzadeh et al.

The concentration of 5×10^{13} cm $^{-2}$ nitrogen in the interface of silicon oxynitride film with the silicon substrate would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose this particular concentration to overcome applicants' admitted prior art constraint, and it appears that the process would possess utility using this concentration.

(10) Response to Argument

In response to appellant's arguments on page 13 that “the substrate beneath film 95 in each of these figures is flat” and “therefore, bird's beak oxidation owing to the post oxidation becomes insufficient”, the examiner agrees on the first statement. However, the rejection is not used appellant's admitted prior art figs. 15B and 15C. The examiner uses the structure of admitted prior art fig. 15A and appellant's admission of “the structure obtained in the previous steps is subjected to an oxidation process”. The first three steps of claims 8 and 12 are the description of forming the structure of instant fig. 15A. Appellant does not provide in claims 8 and 12 any condition so that “bird's beak

oxidation owing to the post oxidation becomes insufficient" but the outcomes of oxidation. One of the reasons of disagreement to the above second statement is provided in the rejection, in that "there must be some degrees of swelling of bird's beak formation under many variable parameters such as the concentration of nitrogen in the silicon nitroxide film at the gate dielectric layer is not high enough". Other reasons could be list such as the heat applied when oxidation is not high enough or the concentration of oxygen in the duration of oxidation is not high enough in a long enough timing, or the pressure during oxidation, to name a few. Further, the term "insufficient" from the instant specification (not in the claims) does not provide a hundred percent insufficiency of the post-oxidation step in the process as a whole. Then and therefore, the examiner refers to the Hisamune reference's recognition of the bird's beak formation in conventional prior art as a proof to show the "insufficiency" in appellant's assertion is not totally correct with Wolf's backing of lowering the surface of the substrate among other limitations.

Also on page 13, it is agreed that "the cited portion of Hisamune is silent as to an insulating film including silicon and nitrogen" because that part of the rejection concentrates on the sufficiency of post oxidation. Appellant is directed to Hisamune col. 1, lines 24-44 wherein "an oxide layer, with a thickness of around 50 nm of silicon dioxide <u>and</u> a silicon nitride layer with a thickness of around 100 to 400 nm ... The LOCOS technique involves a bird's beak problem, which limits the scaling down of the cell array structure." That passage combines with Wolf's page 211, lines 15-16 (extracted in the above rejection) and appellant's admitted prior art structure of instant

fig. 5A is the starting structure for post oxidation which provides the sequels as in the fourth step of claims 8 and 12.

In response to appellant's argument on pages 14-15, the examiner does not use the denied result of the post oxidation in appellant's admitted prior art in which the bird's beak is depressed and/or the invention of the Hisamune in which Hisamune teaches a method that forms the gate bird's beak free. The main idea of using the Hisamune reference is to against appellant's assertion of "bird's beak oxidation owing to the post oxidation becomes insufficient". The examiner uses the structure of admitted prior art fig. 15A and appellant's admission of "the structure obtained in the previous steps is subjected to an oxidation process" in combination of the known oxidation process steps of Hisamune (in which a bird's beak is formed) and/or Wolf to have the same causes and effects as claimed; therefore the combination is proper and one reference does not teach away the others and vice versa as alleged. Appellant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.,* 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986).

In response to appellant's argument on Aminzadeh et al. reference in pages 16-18, it seems that appellant requires Aminzadeh et al.'s figs. 2 and 6 must be exact

drawings of instant invention and ignores the argument/reason in the text of the references to be combined.

Aminzadeh et al. teaches "the structure of FIG. 2 to improve the hot carrier resistance without degrading performance, side oxide 201 is an RNO (re-oxide nitrided oxide) film that not only covers the sidewalls of gate 202, but also replaces gate oxide 203 between LDD region 204 and spacer 205" and "the poly reox step forms oxide 600 on the surface of gate electrode 403, and also increases the thickness of gate oxide 404 over the areas that will become the source and drain regions" those passages combine with Wolf's fig. 3 on page 202.

The reason for the statement of "the evidence/indication of "lowering the surface" is supported by Wolf et al.'s fig. 3, page 202" is not stand alone but with *"both nitride and nitroxide films serving as the gate dielectric" (Wolf's page 211, lines 15-16)* and Wolf's teaching of oxidation processes. Even in fig. 3 the insulating layer is SiO_2, the concept of thermal oxidation is the "original Si interface" (term used in the figure) is lower when the surface of the "silicon substrate" covered by the insulating layer being oxidated/oxidized. More oxide radicals, atoms, ions or molecules (depends on the method used) being corporate into the insulating materials would swell the insulating layer, not only upward but also downward (because they combine with the substrate material); therefore, the original surface of the semiconductor substrate at interface between the substrate and the insulating layer is lowered. The part of the insulating layer underneath the gate is not affected by oxidation as the gate acts as a mask in

oxidation process. Besides, the concentration of any material in that insulating layer, different than the oxygen, is lower (re claim 8's last sequel).

Aminzadeh et al. concentrates on the swelling corner of the insulating layer at the corner of the gate shows the swelling up of the insulating layer 404 outside layer 600 in fig. 6 and the two bird's beak at the two corners (one at the corner of 600 and 403 and another at the corner of 404 and 600) and a bird's beak in between 201, 202 and 203 in fig. 2. The passages from Aminzadeh et al. in combination with Wolf above further explain the corroborated assertion of the combination in the rejection.

In response to the argument on page 19, appellant's arguments again against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.,* 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Though Wolf presents some disadvantages, Wolf teaches remote plasma oxidizing method (figs. 6, 7 and 8 on pages 170, 171 ands 172 respectively) and Hisamune's prior-art recognition "in the oxidation processes, <u>oxygen radical</u> created within a furnace easily diverges <u>through the separating regions</u> in the form of silicon dioxide and <u>reaches</u> the gates... This encroachment of the oxide into the bottom of the gates is known as a 'gate bird's beak' because of its shape when viewed in cross-section (col. 2, line 64 to col. 3, line 7)" (extracted from the above rejection) is used in the rejection section related to oxygen radicals and remote plasma oxidizing method.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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04/13/2006

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